Directorate of
Intelligence

~~Top Secret~~ 34

File

25X1

25X1

Soviet Industrial Automation: Flexible Manufacturing

25X1

An Intelligence Assessment

~~Top Secret~~

SW 86-10058CX
SOV 86-10058CX

25X1

December 1986

Copy 240

Page Denied

Directorate of Intelligence

Top Secret
[redacted] 25X1

Soviet Industrial Automation: Flexible Manufacturing [redacted] 25X1

An Intelligence Assessment

This paper was prepared by [redacted] 25X1
[redacted] the Office of Soviet Analysis and [redacted] 25X1
[redacted] the Office of Scientific and 25X1
Weapons Research. [redacted] 25X1

Comments and queries are welcome and may be directed to the Chief, Technology Transfer Assessment Center, OSWR, [redacted] 25X1
[redacted] 25X1

[redacted]

Reverse Blank

Top Secret 25X1
SW 86-10058CX
SOV 86-10058CX
[redacted] 25X1
December 1986

25X1

Soviet Industrial Automation: Flexible Manufacturing

25X1

Key Judgments

Information available as of 1 August 1986 was used in this report.

A key element in the Soviets' long-range objective to modernize their defense and civil industries is the development, production, and acquisition of flexible manufacturing systems (FMSs). FMSs—clusters of fully automated machine tools and associated material-handling equipment under the direction of a supervisory computer—shorten leadtimes, increase and sustain quality, and reduce labor and other resource costs. FMSs are particularly attractive in weapons and machine-tool manufacturing because they are best suited to batch production of highly complex and precise parts. We believe, as do the Soviets, that use of FMSs is essential to avoid prohibitive demands on resources and serious industrial bottlenecks as complex components for new weapons and high-technology civil products proliferate in the 1990s. 25X1

The development of flexible manufacturing technology in the USSR began later than in the United States. 25X1 25X1 The Soviets claimed 25X1 publicly in 1984 that they had 60 FMSs in operation. But this number included less capable machining modules, cells, and semiautomated lines that lack the computer support essential to Western FMSs. 25X1

General Secretary Gorbachev's industrial modernization program calls for more rapid development and application of FMSs. Thousands of the relatively simple flexible production modules and cells are to be installed by 1990. This emphasis on quantity over quality, however, is likely to severely diminish the productivity gains that Western-style FMSs provide. To optimize performance, FMS applications must be tailored to each customer's specialized needs. 25X1

The Soviet Union lags the West by as much as 10 years in some areas of flexible manufacturing technology. The Soviet approach to modernization through the proliferation of single-machine-tool modules will improve the Soviet manufacturing environment. However, this approach will not allow the Soviets to narrow the gap with the Western state of the art in flexible manufacturing technology. 25X1

Gorbachev's agenda faces serious challenges because of technological deficiencies in the Soviet industrial base:

- Serious lags in key FMS technologies—computers, software, computer-aided-design (CAD) systems, and data storage.

[redacted] 25X1

- Problems with machine tool quality and production. Annual Soviet output of machine tools with computer numerical control—the building block of flexible production systems and modules—totals only a few hundred and usually depends on Western-produced units with computer numerical control (CNC).

- The absence of trained engineers, industrially based computer specialists, and managers who both understand and support FMS technology—making it difficult to integrate FMS technology into the typical Soviet plant environment. [redacted] 25X1

To offset these problems, the Soviets have been acquiring flexible manufacturing technology from both Eastern Europe and the West. Soviet domestic research and development and production programs for FMSs have been supplemented by engineering support and imports of flexible production modules, robots, microcomputers, and advanced machine tools from Eastern Europe. But the greatest impact comes from Western FMS imports, which include technical assistance, more capable control systems, and sensors. [redacted] 25X1
25X1
[redacted] 25X1 Many of these acquisitions include aftersales training support. Numerous other advanced machine tools being purchased can be integrated into an FMS. In addition, the Soviets are negotiating for turnkey plants to design and manufacture FMSs. [redacted] 25X1

[redacted] 25X1

We believe the Soviets need a continued infusion of Western technology if they hope to achieve their long-range objectives in FMSs. The United States and its COCOM partners over the last five years have embargoed the sale of machine tools capable of linking to FMSs and some industrial

 25X1

computers. Recently, an export control agreement was reached on software for certain types of FMSs. 25X1

25X1

We believe that combining increased Soviet production with additional Western technology will produce mixed results in the next decade. Key defense and civilian plants—for example, the major Soviet machine-tool enterprises—could emerge in the early 1990s with considerable capacity for CNC machining. The benefits for much of the rest of Soviet industry, however, are far less certain. Even if the Soviets were able to produce and install thousands of the simpler numerical control–based modules, cells, and hybrid lines, they probably would not achieve full manufacturing flexibility. Only radical changes would enable the Soviets to lay a solid basis during the next five years for the diffusion and integration of medium-level and advanced FMSs throughout industry as a whole. We believe the integration of design and engineering functions with production or machining activities—or factory automation—will be severely limited in the USSR until the year 2000. 25X1 [redacted] 25X1

Contents

[redacted]

[redacted] 25X1
25X1

Reverse Blank

Sanitized Copy Approved for Release 2011/08/23 : CIA-RDP89T01363R000300340005-9

Soviet Industrial Automation: Flexible Manufacturing

25X1

25X1

Introduction

Since General Secretary Mikhail Gorbachev came to power, he has pushed to modernize the Soviet economy by accelerating the use of high-technology industrial processes. Gorbachev is pressuring Soviet machine tool makers to produce unprecedented numbers of flexible manufacturing systems (FMSs). The high priority afforded this technology is reflected by the dismissal in July 1986 of Minister of the Machine Tool Building and Tooling Industry Bal'mont, who had proposed significantly lower FMS production targets rather than aggressively implementing Gorbachev's ambitious goals set in the 12th Five-Year Plan (1986-90).

This study outlines the Soviet approach to metalworking FMS technology and the challenges the Soviets face in their drive for widespread use of FMSs. The technology deficiencies that Soviet industry must overcome to build critical FMS components in the large numbers required are described. The importance of East European cooperation and the acquisition of Western technology are assessed, as well as the likely applications and the benefits we expect the Soviets to reap from these. Finally, the paper assesses the outlook for future development and application of flexible manufacturing in the USSR and its implications for industrial productivity.

We have relied heavily on Soviet published sources for information on Soviet domestic development and production of FMSs and their chief features, especially in the civilian sector of the Soviet economy. The open literature is a particularly rich source at the present time because of Gorbachev's new policy of "openness." However, we found inconsistencies in definition, product identification, and reporting on output, stemming from the fact that the Soviets and their East European allies are only in the early stages of applying this new manufacturing technology.

Background on FMS Technology

Clarifying Terms. The term FMS most commonly refers to a cluster of fully automated machine tools or other metalworking machines under the direction of a supervisory computer. Generally, a system includes equipment for automated tool changing and part loading and unloading (with the help of robots and automated guided vehicles—AGVs), in addition to a computer that directs basic fabrication processes (see figure 1, in pocket). 25X1

25X1

In this paper we classify Soviet flexible manufacturing systems into three types:[1]

- Flexible production module, composed of one machine tool with pallets or robots for part loading and unloading.
- Flexible production cell, composed of two or three linked machine tools with material-handling equipment. 25X1
- Flexible production system, composed of four or more machines with a material-handling and parts storage system (appendix A). 25X1

25X1

25X1

[1] The most widely used Soviet terms are *qibkiy proizvodstvenniy modul'*, or GPM (flexible production module); *qibkiy proizvodstvenniy liniya* and *qibkiy proizvodstvenniy uchastok*, or GPL and GPU (flexible production line and flexible production section); and *qibkiy proizvodstvenniy tsekh*, or GPTS (flexible shop). The Soviets lump together cells and full-scale FMSs under GPU, and include hybrid transfer lines under GPL. 25X1

25X1

25X1

Although this categorization suggests that the number of machine tools is the key factor, the critical element really is the flexibility of the control system—its capability to machine, handle, and inspect a mixed batch of tens of distinctly different parts in a variety of ways without interruption. This flexibility requires sophisticated software and computer-numerical-control (CNC) units.[2] The Soviets, however, consider clusters of machine tools, some manually operated, as well as single machine tools or "modules," none of which use supervisory computer control, to be flexible manufacturing equipment. These would not be classified as FMSs in the West.

Benefits to Users. Flexible manufacturing offers many benefits. FMSs provide the flexibility to respond to shifts in customer demands or changes in engineering design. The higher level of automation, the reduction in the number of machines and machining steps required, and greater emphasis on part/machine alignment typically result in much greater repeatability for closer tolerances. These characteristics also reduce scrap and rework costs. Computer control of parts flow maximizes equipment use, in many cases doubling the use rate achieved in conventional manufacturing. Efficient computer scheduling, more processing on each machine, and closer machine spacing reduce work-in-process inventories. Spare parts inventories can be cut sharply: small batches of parts—even one part at a time—can be produced as needed because cutting instructions are stored on a computer.

FMSs are designed for small-to-medium batch production in a variety of manufacturing applications. In the West the largest number of systems have been used in metal cutting, primarily in machine tool plants and in engine plants. They are also used in sheet metal fabrication, which requires computer-driven automation of automatic punch presses, and laser cutting machines. FMSs are also applied in die-set-type metal forming, although automation of parts handling is difficult when the presses are large and part of the weight is in tons. Flexible assembly is a growing application and, because assembly operations usually account for the largest share of manual labor, may yield the greatest benefits. 25X1

FMSs are ideally suited for defense industry applications, such as airframe and engine part fabrication; the milling and finishing of tank hulls, turrets, and guns; and the fabrication of mechanical components and subassemblies of other ground, air, and naval weapons systems. Defense customers typically place a premium on minimizing leadtime between design and manufacture and on maintaining high-quality standards, and FMSs deliver these features. Many defense products and machine tools also require highly complex and precise parts in relatively small numbers. For programs that require tens of thousands of less precise parts, inflexible "hard automation," such as transfer lines, is cheaper and therefore more appropriate. 25X1

25X1

Soviet FMS Development, Production, and Acquisition

Development Strategy. The Soviets have adopted a national program for the development of computerized flexible manufacturing. After experimenting in the 1970s, the Soviet Government initiated a series of steps beginning in 1980 that culminated in legislation issued in May 1984. This legislation: 25X1

- Defined various types of computer-automated FMSs.
- Delegated responsibilities for R&D and production.
- Set goals for the production of FMSs for the period of the 12th Five-Year Plan (1986-90). 25X1

Under the legislation, the State Committee for Science and Technology (GKNT) was charged with developing a national program of fundamental and applied scientific research for the long-range development of FMSs. The legislation directed the Ministry of the Machine Tool Building and Tool Industry (MINSTANKOPROM) to spearhead the drive to

[2] A CNC unit is a microprocessor-based controller that provides the control signals to the motors that move the various parts of the machine tool. Numerical control (NC) units provide the same control signals, but lack the microprocessor. Unlike the NC unit, the microprocessor allows the CNC unit to connect directly to a supervisory computer and permits the programming of the cutting instructions in easy graphical terms rather than lengthy special codes.

25X1

25X1

 25X1

develop and produce FMSs. The Ministry's two major research organizations—the Experimental Research Institute for Metal-Cutting Machine Tools (ENIMS) and the Experimental Research Institute for Metal-Forming Machine Tools (ENIKMASH)—were charged with R&D in flexible metal-cutting and metal-forming systems, respectively. They also were assigned a major role in the installation of new systems, both in the Ministry's plants and elsewhere. Some advanced manufacturers—such as the Soviet machine tool industry's Red Proletarian and Ivanovo plants—were also charged with developing and installing flexible production (FP) systems, the most complex Soviet FMSs. Although the civilian machine tool industry has developed virtually all FMSs, the aviation industry has worked independently on FMS development for its own machine tool plants. 25X1

MINSTANKOPROM, together with the Soviet Council of Ministers' State Committee on Standards (GOSSTANDART), was charged with developing the technical documentation and industrial standards for all types of FMSs and their components by 1986. Finally, a new national commission, the GEKM,[3] was formed to distribute the new equipment primarily to the machine-building and metal-working industries, and to analyze and develop recommendations for improving machine tool use. 25X1

According to official writings, Soviet plans for flexible manufacturing have two basic thrusts:

- Mass production of technologically simpler FP modules, those made up of one NC or CNC machine tool with a pallet changer or robot loader, or FP cells with several NC machine tools.
- Limited production of more complex FP systems, which are to be installed in defense and advanced civilian plants. 25X1

The former head of the Soviet machine tool ministry B. V. Bal'mont stated in a 1983 interview that the USSR planned to start with the production of modules "that would have to be loaded and programmed with operator assistance." More advanced systems would "operate automatically." We believe that only the latter systems may be able to use a host computer to integrate advanced materials handling, computer-aided design (CAD), inspection, or dedicated part storage. 25X1

25X1

25X1

Soviet publications emphasize the automation of the transport and parts-handling aspects rather than the control network, which entails more novel technologies. However, in one instance, the Soviets have mentioned production planning on a separate computer. 25X1

[3] The State Consultancy Commission on Issues Relating to the Distribution and Utilization of Metalworking Equipment in the National Economy, which is a subcommittee of GOSSNAB, the Soviet distribution agency for technical and material resources. 25X1

[4] According to Ryzhkov, the USSR produced 183 flexible automated *(avtomatizirovannyy)* systems and 3,400 flexible modules in 1985. The definition used in this count was not specified. These Soviet production figures most likely represent equipment clusters in areas such as woodworking, textile manufacturing, or material handling—not flexible systems in the Western sense. 25X1

 25X1

The most sophisticated FP system observed to date—the latest version of the Talka 500 from Ivanovo—was an exhibition model shown at the Metal Working 84 Exhibit in Moscow. This system incorporated three machine tools, each with a different Western-made CNC unit, and was linked to a coordinate measuring machine.[5] [redacted] the Soviet-made SM-4 host computer was intended to monitor machine operation for management statistics, to download various parts programs, and to maintain quality control. There was no indication of a CAD system or parts programming. We do not know whether the Talka 500, which was only demonstrated at an exhibition, could actually operate on the shop floor. However, the system demonstrates the Soviets' intentions to develop FMS using a variety of Western CNCs with a Soviet computer. [redacted]

The Soviets have not yet achieved their goal for mass production of FP cells and modules. [redacted] But the addition of explicit FMS production targets to the 12th Five-Year Plan indicates that the pressure to deliver is mounting. The plan includes requirements for nonmetalworking industries to install FP modules, cells, and systems not based on machine tools but on woodworking, textile, or other machinery. The total for all industries—metalworking and nonmetalworking—is 1,800 FP systems and 30,000 FP modules and cells during 1986-90. [redacted]

Technological Limitations for Development and Production. We believe the Soviets are deficient in several technologies that are key to FMS development and production. These deficiencies, which have impeded Soviet progress to date, include computer technology and engineering, machine tool quality, CNC-unit production, CAD technology, automated inspection, and integrating robotics. [redacted]

Endemic computer technology deficiencies severely limit Soviet development and production of FMSs. These deficiencies include an inadequate supply of reliable computer hardware, a severe shortage of software engineers to create and correct programs, and an inability to store electronic information reliably. [redacted] 25X1

The absence of engineers, industrially based computer specialists, and managers who both understand and support the new technology severely impedes Soviet efforts to implement flexible manufacturing. The Soviets have launched a nationwide program to overcome computer illiteracy, but it is not expected to bear fruit until the 1990s. The machine tool ministry has begun to retrain some 1,000 engineers from its plants annually in numerical control technology and robotized equipment. These programs, however, are not likely to enable the key manufacturing sectors to acquire the expertise required for widespread installation of flexible manufacturing with its higher level software requirements. [redacted] 25X1 25X1 25X1 25X1 25X1 25X1 25X1

The low quality of production in the machine tool ministry also inhibits Soviet efforts to produce and install FMSs. In 1984 approximately 50 percent of the ministry's plants were ordered not to ship their machine tools because of poor quality. The ministry produced only 60 percent of its quota of NC machine tools last year and an even smaller percentage of advanced equipment, such as CNC machine tools with automatic tool changers. [redacted] 25X1

Soviet annual production of machine tools with CNC units is only in the tens or hundreds because of a shortage of CNC units. CNC machine tools are an essential building block for FMSs. The deficiency in CNC units is principally because of severe shortages in Soviet microelectronics technology. [redacted] 25X1 25X1

[redacted] 25X1 25X1

[5] A coordinate measuring machine is a testing device that measures both cylindrical and prismatic parts after they have been fabricated. These computer-controlled devices enable the data and the corrections to be fed back directly into the automated production system. [redacted] 25X1

The Soviets are a decade behind the West in CAD systems, an important factor in achieving the full impact of flexible manufacturing on a factory-wide scale. In addition, they produce very few computer graphics workstations for the preparation of NC parts programs and have increased their imports of Western systems. [redacted] The Soviets are 10 years behind the West in disk-drive technology, and their inability to retrieve reliably electronic data limits sharply the amount of design files and production programs that can be managed. As a result, the FMS is limited in flexibility and scale, and the design process remains time consuming. [redacted]

Rapid development and production of FMSs are also impeded by the Soviet lag in automated inspection technology. Automated in-process inspection requires electromechanical devices; acoustical, tactile, and force-sensing probes; and vision devices. We believe that no indigenous source manufactures in-process measuring probes in the USSR. For postprocess automated inspection, the Soviets produce only a small number of coordinate measuring machines, relying heavily on Western imports. [redacted]

A lag in robotics technology further hampers the Soviet drive for FMSs. The Soviets currently import both sophisticated freestanding robots and manufacturing systems based on simple robots. They have implemented R&D and cooperative production arrangements with Bulgaria, Czechoslovakia, Hungary, and East Germany. Incorporating FMS technology into nonmachining areas, particularly assembly, will require far more sophisticated robotics technology than the Soviets are currently producing. As a result, the Soviets are not likely to have FMSs in nonmachining-based industries for years to come. [redacted]

East European Contributions. In an effort to overcome these limitations, the Soviets have turned to their Eastern Bloc partners—primarily for components that could be used in larger systems. The East European nations as a group constitute the largest source of machine tools for the USSR, accounting for 69 percent of total machine tool imports in value. In addition, they have shipped robots, controllers, and microcomputers. The reliability of this equipment will help improve the Soviet manufacturing environment. However, it would require a major effort for the Soviets to integrate this equipment into FP systems on a regular basis because of their weaknesses in computer network and systems engineering. [redacted]

The East Europeans have only begun developing FMSs for export, partly in direct cooperation with leading machine tool plants and research labs in the USSR. The primary emphasis is on the production of large numbers of the simple FP modules and cells—a program similar to that in the USSR. [redacted]

Several East European countries—particularly East Germany and Czechoslovakia and, to a lesser extent, Hungary—have done considerable work in developing flexible manufacturing technology (see appendix C). Others, such as Bulgaria, have tried to acquire state-of-the-art Western technology to support their domestic efforts as well as their obligations to the USSR. Strengths that the Soviets will probably rely on include Hungarian modeling and software capabilities, Bulgarian FMS components, Czechoslovak experience with installation and operation of machining systems, and East German expertise with precision machining and quality control. [redacted]

[redacted] the capacity of the East European machine-tool builders to install and sell FMSs has been inhibited by:

- Backwardness in FMS support technologies—such as computers, software, robotics, and advanced machine tools.
- Investment shortages that have restricted the supply of critical computer hardware and complementary technologies.
- Negotiated commitments to build lower-level special machine tools or NC equipment for the USSR in large numbers. [redacted]

25X1 25X1 25X1 25X1 25X1 25X1 25X1 25X1 25X1 25X1 25X1

Page Denied

Next 3 Page(s) In Document Denied

25X1

The only Soviet-designed FP system whose benefits have been extensively described is the aircraft industry's ALP-3-2. According to the Soviet press, these benefits included a cutback from 16 to eight machining centers, decreases in tool changing time, reduction from 91 to 47 people, and reduction of production time from 45 to six days. The machines were operated on a three-shift basis, and the Soviets claimed to have saved 700,000 rubles. The savings in machine tools and labor may well be accurate, but the cost savings are questionable. The Soviets failed to cite the hidden costs, such as those for the host computer, automated transport, or instrumentation, and those for the new kinds of maintenance and computer-related services required.

The benefits generated by primarily imported FP cells and systems are especially important to development and production of new Soviet weapon systems. FMSs can provide the necessary machining quality to achieve the increasingly complex designs of modern weapon systems. These designs drive toward subsystem miniaturization and overall increased structural strength with reduced weight. Production of these systems demands highly reliable computer-aided designing and its linkage to extremely precise, computer-controlled manufacturing equipment. FMSs also could help the Soviets offset the steady increases in the cost of weapons manufacturing.

Outlook

We believe the Soviets will increasingly require FP cells and systems as their defense production grows in variety and complexity and their need for rapid changeover in production lines grows. However, our study shows that they will fall short of their production goals. It is unlikely that they can mass-produce FP modules and cells within the next four years when so few of the building blocks for integrated manufacturing systems—CNC machine tools, computers, and components—are available in the USSR. (NC machine tools currently constitute only 7 percent of the total annual Soviet machine-tool output, and the USSR currently produces probably no more than a thousand CNC metal-cutting machine tools annually.) It is even more unlikely that in each of the next four years the Soviets will be able to develop and install hundreds of the much more complex FP systems. Even Bal'mont's conservative development plans—to install 11 FP systems in ministry plants in 1986—seem overly optimistic considering that eight Soviet FP systems were produced in all of the USSR from 1980 to mid-1986.

25X1

25X1

25X1

25X1

The Soviet leadership faces formidable constraints in its efforts to install FMS technology on a nationwide basis during the next decade. The difficulties stem from the usual institutional impediments to all technological innovation in the USSR.[8] Special deficiencies in the heavily computer-based supporting technologies and personnel include the lack of industrial computers, data bases, and local area networks, software, and the personnel capable of designing, installing, servicing, and operating integrated manufacturing systems. Moreover, shortages of components critical to FMS production span the entire range of CNC machine-tool technology, robotics, and sensors.

25X1

Moreover, Soviet managers are not used to applying a systems approach in modernizing their plants. The introduction of flexible manufacturing systems requires an integrated approach that considers the

25X1

[8] These impediments include centralization, barriers between applied research and production, heavy investment in construction and other basic industries, traditional manufacturing practices, and dysfunctional managerial incentives.

25X1

25X1

25X1

entire operation rather than a specific piece of equipment. Current Soviet industrial management practices instead depend on replacing machinery piecemeal while concentrating on fulfilling monthly or annual production quotas.

We believe that in the next 10 years the Soviets will continue requiring Eastern Europe to help supplement their own efforts to modernize machinery production. The Soviets will probably increase their imports of FMS components, such as pallet changers, robots, controllers, and computers. A number of joint R&D projects in flexible manufacturing are already in place with East European machine-tool manufacturers. The Soviets could benefit from Hungarian modeling and software capabilities, Bulgarian FMS component manufacture, Czechoslovak experience with installation and operation of machining systems, and East German expertise with precision machining and quality control. We do not know how heavily the Soviets can rely on the East Europeans because their capacity—or willingness—to cooperate with the Soviets is constrained by financial and technical factors and by their desire to modernize their own industries.

25X1

In addition, the Soviets will continue in the near term to aggressively seek advanced machinery and technical assistance from the West. Our study suggests that the Soviets will continue heavy purchases in flexible manufacturing technology, despite hard currency shortages. However, we expect that the USSR will increasingly encounter more difficulty in purchasing Western FMS technology than it did in acquiring single stand-alone machine tools in the past. The export to the USSR of important components in FMS such as computers, software, CNCs, and compatible machine tools is controlled by COCOM. The Soviets have been successful in acquiring these components, nonetheless. We believe that the Soviets' lack of experience with the more complex Western systems will lead to increased installation time, general engineering problems, and other difficulties in integrating the systems, however.

25X1

In summary, we believe that the Gorbachev program will show mixed results in the next decade. Key defense and civilian plants—for example, the major Soviet machine-tool enterprises—could emerge in the early 1990s with considerable capacity for CNC machining. The benefits for much of the rest of Soviet industry, however, are far less certain. Even if the Soviets were able to produce and install thousands of the simpler NC-based modules, cells, and hybrid lines, they probably would not achieve full manufacturing flexibility. Only radical changes would enable the Soviets to lay a solid basis during the next five years for the diffusion and integration of medium-level and advanced FMSs throughout industry as a whole. We believe the integration of design and engineering functions with production or machining activities—or factory automation—will be severely limited in the USSR until the year 2000.

25X1

25X1

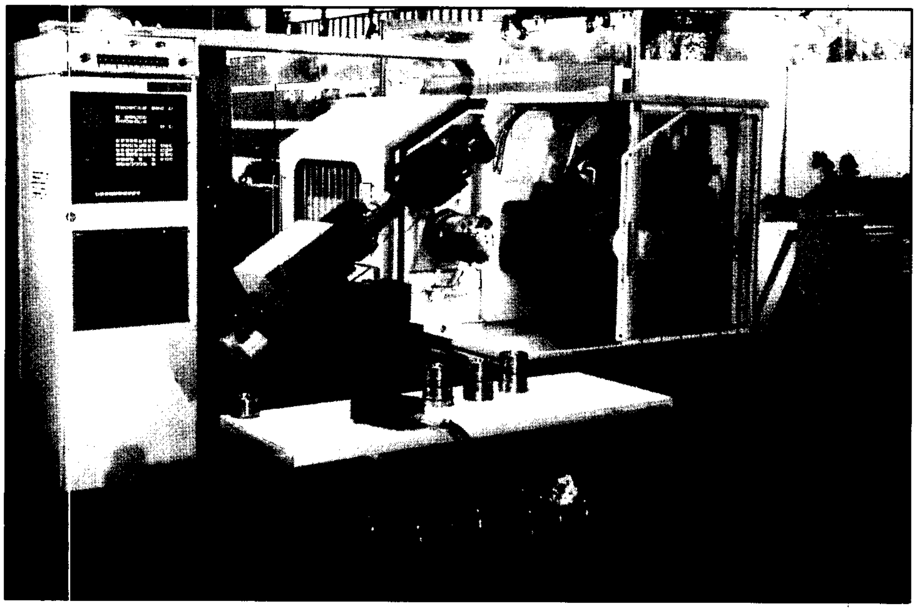
25X1

25X1

Appendix A

Representative Soviet Flexible Manufacturing Systems

Figure 3
Flexible Production Module: Turning Center With Robot



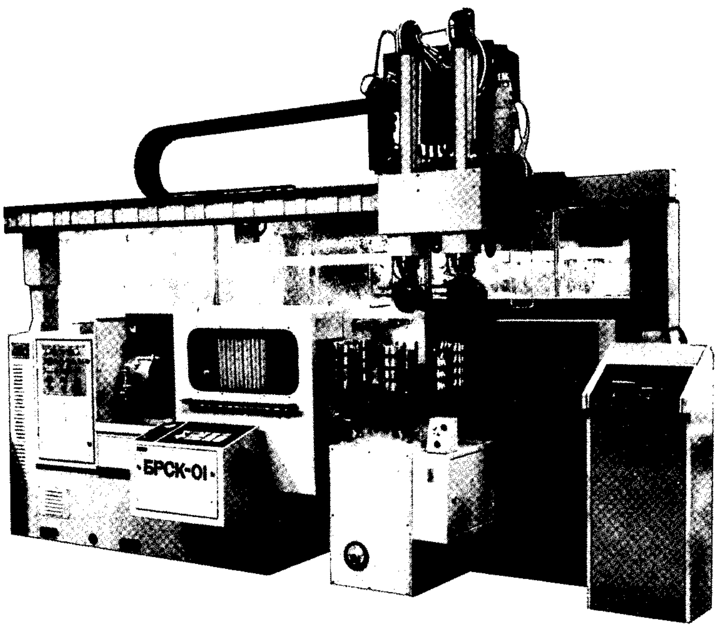
This module is typical of the simplest type of Soviet flexible manufacturing system. The Soviets hope to produce these modules in quantities of tens of thousands in the next five years. Pioneered by the Srednevolzhsky Machine Tool Plant, the module is based on an NC lathe (type 1716PF3) wedded to a pick-and-place robot. It contains two measuring probes, one for measuring the workpiece dimensions and one for measuring tool wear. The NC system accepts the program entry from punched tape or a keyboard.

310912 11-86

25X1

25X1

Figure 4
Flexible Production Module: Turning Center With Robot and Pallet



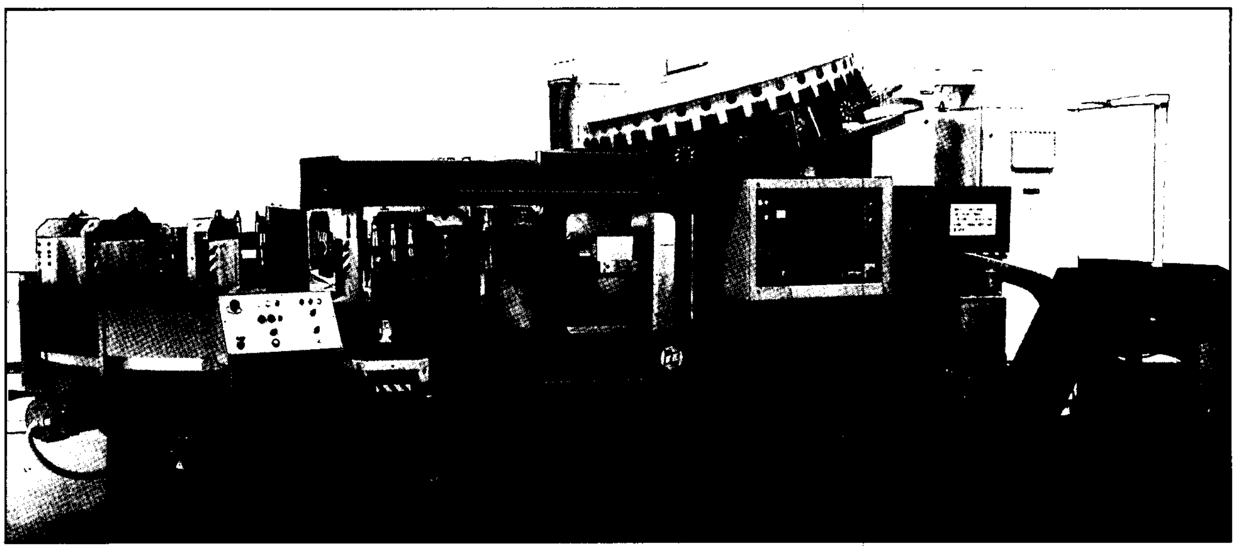
This module is designed to process short rotational parts with straight or curved profiles or threads. Produced by the Komsomolets Machine Tool Plant in Berdichev, it consists of an NC turret lathe (type 1B340F30), a gantry-type double-arm workhandling robot, and an eight-position pallet table. The NC system allows the parts program to be devised on the spot. The program is checked and edited as the trial part is machined, and it includes work loading and unloading.

25X1

310913 11-86

25X1

Figure 5
Flexible Production Module: Machining Center With Pallets



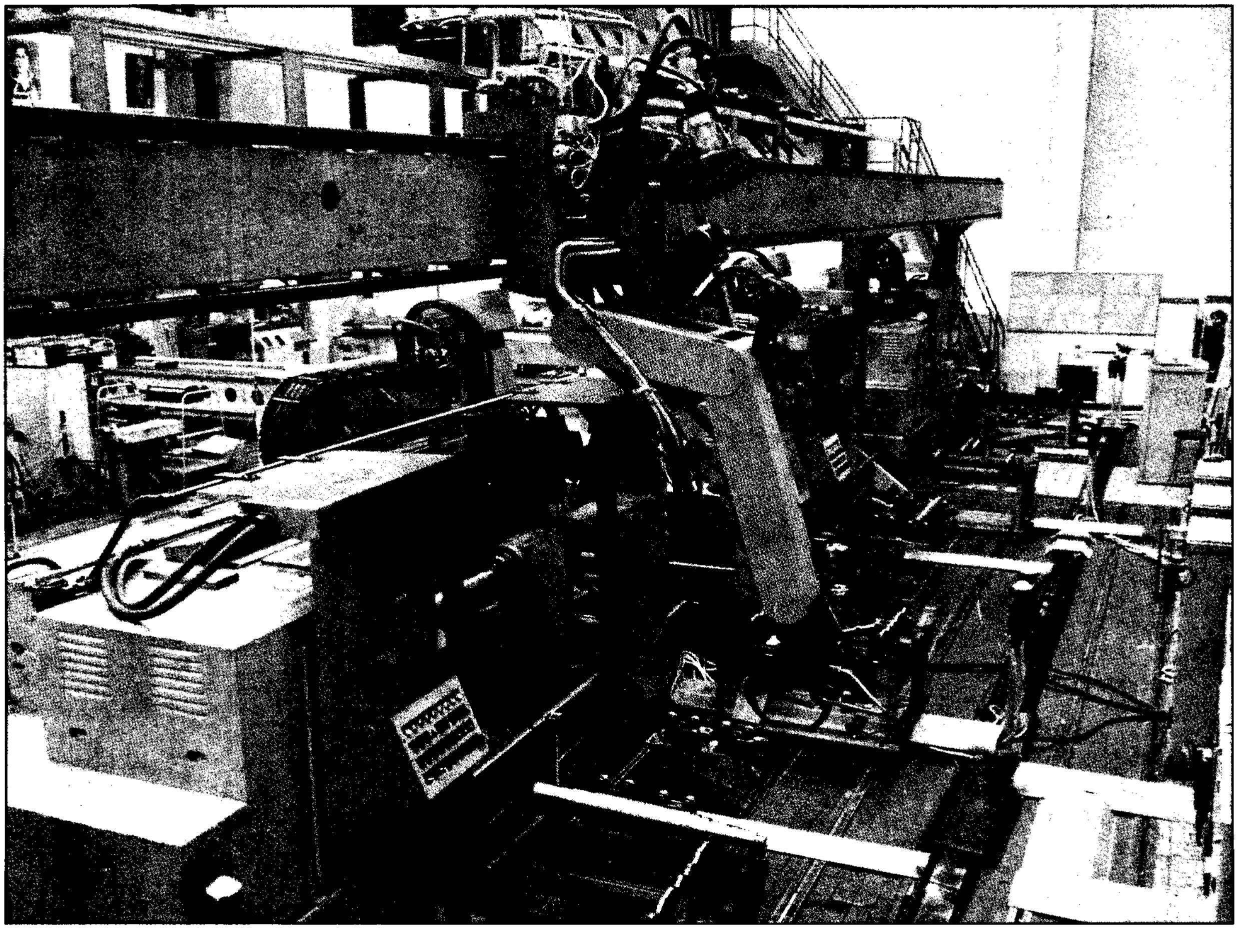
This version, produced by the Ivanovo Machine Tool Plant, consists of a machining center (type IR320PMF4) with a 12-position carousel-type pallet magazine. It is designed for accurate machining of intricate cube-type parts. It can be incorporated into larger FMSs and represents the state of the art in the USSR.

310914 11-86

25X1

25X1

Figure 6
Flexible Production Cell: Three Turning Centers With Robot



This automated section is used for turning shafts for electric motors in the Kirov (Dynamo) Plant in Moscow. The cell consists of three NC lathes (type 1B732F3) and a gantry-type robot (type UM160F2.81.01). The assembly was designed with the help of the national lab for metal-cutting tools, ENIMS, a leader in the development of flexible manufacturing in the USSR.

310915 11-86

25X1

Page Denied

Next 9 Page(s) In Document Denied

Appendix C

East European FMS Development Capabilities

East Germany
East Germany is the leading FMS producer in Eastern Europe. Its preeminence in advanced machine-tool technology stems from three factors: a machine-tool manufacturing capability that predates World War II, the strongest economy in Eastern Europe, and Eastern Europe's best microelectronics industry. East Germany was one of the pioneers in numerically controlled machine-tool technology, and by 1970 it was exporting 80 percent of its NC tools to the USSR and providing technical help.[9] It was an early developer of flexible manufacturing systems, and its Prisma II, completed in the late 1970s, is probably Eastern Europe's showcase FMS. [redacted] East German embassies have installed thus far six FMSs, largely of the direct numerical control (DNC) type in which parts programs are simply downloaded.[10] They have delivered an FMS to the Soviet automotive works in Minsk and have built a robotized turning center module jointly with the USSR. [redacted]

Czechoslovakia
Czechoslovakia has a long history of machine-tool manufacture, although its machine-tool industry is not as advanced as East Germany's. The Czechoslovaks began work on flexible manufacturing in the late 1970s. They now have an ambitious program of building FMSs. [redacted]

Czechoslovakia is second only to East Germany in exporting machine tools to the USSR, shipping more than 50 percent of its machine-tool production there.

[redacted]

The Czechoslovaks have been shipping components for machine tools that form "building blocks" to FMS, including controllers and other machine-tool components such as transducers, ballscrews, and electric drive systems. [redacted] 25X1

[redacted] 25X1 25X1 25X1

Czechoslovak-Soviet cooperative projects involving flexible manufacturing include a new international scientific and technical association for robotics R&D established in Preslav. [redacted] 25X1

Hungary 25X1
We believe that, of the remaining CEMA (the Council for Mutual Economic Assistance) partners, both Hungary and Bulgaria make a smaller contribution to Soviet efforts in flexible manufacturing. Hungarian software for three-dimensional surface modeling will help design parts and create cutting programs for machine tools. [redacted] 25X1 25X1 25X1

[redacted]

Although Hungary has the smallest machine-tool industry and exports fewer machine tools to the USSR than other East European nations, it has begun to contribute to Soviet machine-tool modernization. 25X1
According to press reports, the Hungarians have

[10] DNC involves a central computer that only downloads part programs to a group of machine tools. The computer does not control transport, inspection, or part flow scheduling. [redacted] 25X1

already shipped hundreds of machining centers to the USSR since 1984. They have signed an agreement for providing 14 FMSs to the Soviets. [redacted] the system to the simplest modular form. Press reports indicate that work has begun on producing flexible lathe modules using a Hungarian machine tool and a Soviet robot, with the first system scheduled to start operations in a Soviet plant in 1987. [redacted]

Bulgaria

Bulgaria is also participating with the USSR on joint projects for manufacturing modernization. Currently, joint design work is carried out between Soviet and Bulgarian machine-tool research institutes. In October 1985, arrangements were negotiated for joint production of flexible machining modules for both cylindrical and prismatic parts between four premier Soviet and Bulgarian production associations, most of which will be sent to the USSR. The Soviet Machine Tool Production Association and Bulgaria's State Economic Association Machine Tool Plants (DSO-ZMM) will produce machining-center-based flexible modules for fabricating prismatic parts, while the USSR's premier manufacturer of lathes, the Red Proletarian Machine Tool Building Production Association, and Bulgaria's Beroe Robotics Research and Production Complex will jointly manufacture modules centered on turning centers and robots. [redacted]

Yugoslavia

Although not a member of CEMA, Yugoslavia has also contributed to Soviet industrial modernization. The USSR receives annually between 50 and 70 percent of Yugoslavia's total machine-tool exports. Control systems manufactured in Yugoslavia have been sent by the hundreds to Soviet machine-tool plants since the mid-1970s, and Yugoslav plants have also supplied components for NC tools, such as gearboxes and spindle heads. The chief Yugoslav electronic manufacturer, Iskra, has also developed processor controls jointly with the Soviet's national tool lab, ENIMS, for both lathes and milling and boring machine tools. Yugoslavia is also a participant in several CEMA agreements on robots and manipulators. [redacted]

25X1

25X1

25X1

25X1

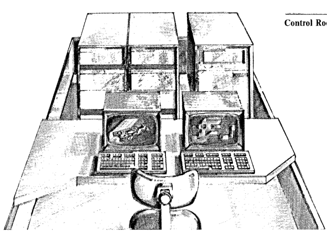
25X1

Page Denied

Next 8 Page(s) In Document Denied

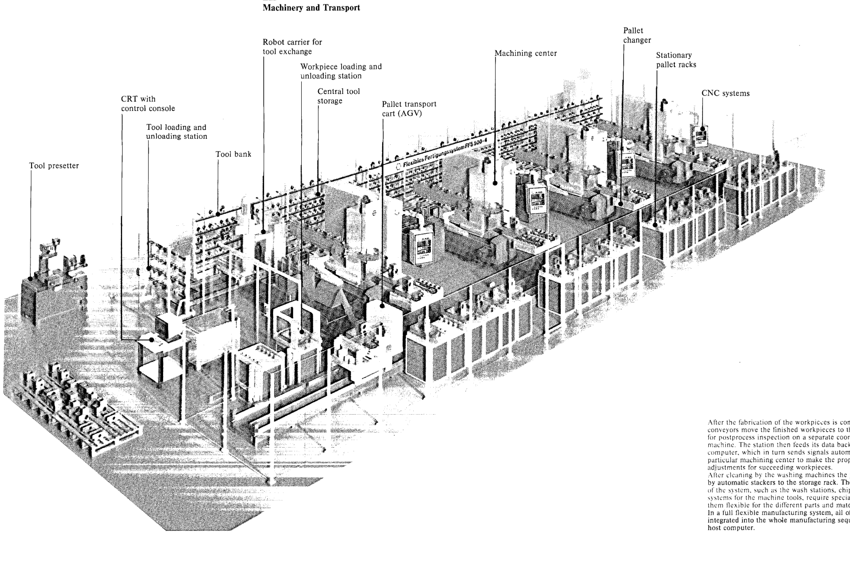
Figure 1
A Typical Flexible Manufacturing System

Control Room



The control room provides integrated computerized management for the whole system. The system shown has two computer-aided design (CAD) stations for the design of parts to be machined and three host computers. One computer monitors the sharpness of tools and the need to replace broken tools; handles CAD planning and scheduling, including the application of group technology software which groups similar parts for machining them in batches; and maintains statistics on machine usage and efficiencies. Another computer monitors the operations of machinery on line, following a predetermined schedule. A third computer feeds numerical control part programs to the local computer numerical control unit with cutting instructions.

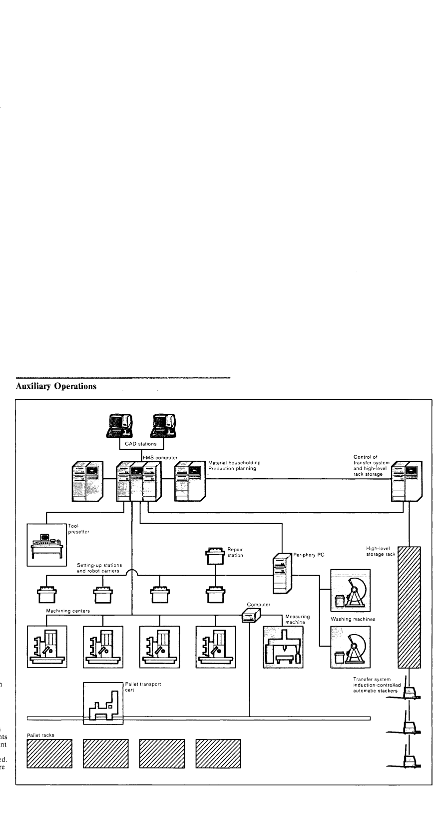
Machinery and Transport



This is the central fabrication system. A series of pallet transport carts deliver parts on pallets or racks from the warehouse or parts storage area to the machining area. The cube-type parts are delivered to the machining centers by the pallet changers. Parts are stored in the stationary pallet storage area.
Tool banks are available at each machine. Different cutting tools are removed or mounted by robot carriers as required. In-process inspection involves the insertion of touch probes from the tool bank into each machining center. This system measures only how accurately parts are being cut as specified by the program. It cannot check the real dimensions of the parts, which is done in postprocess inspection.
Each of the machining centers is operated by its own CNC system, which in turn is responsive to the host computers in the control room.

After the fabrication of the workpieces is completed, AGVs or conveyors move the finished workpieces to the inspection station for postprocess inspection on a separate coordinate measuring machine. The station then feeds its data back to the central computer, which in turn sends signals automatically to the particular machining center to make the proper cutting adjustments for succeeding workpieces.
After cleaning by the washing machines the parts are transferred by automatic stackers to the storage rack. The simpler components of the system, such as the wash stations, chip removal and coolant systems for the machine tools, require special features to make them flexible for the different parts and materials being machined. In a full flexible manufacturing system, all of these operations are integrated into the whole manufacturing sequence through the host computer.

Auxiliary Operations



Page Denied

Top Secret

25X1

Mc

M

N

O

P

Q

R

S

Top Secret